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INVENTOR(S): ANTHONY J. SUMCAD
CHRISTOPHER L. OESTERLING
RUSSELL A. PATENAUDE
HITAN S. KAMDAR
BRAD T. REESER
SHPETIM S. VELIU

TITLE: METHOD AND SYSTEM FOR TESTING CELLULAR NETWORK INTEGRITY USING TELEMATICS

ATTORNEYS: ANTHONY LUKE SIMON, ESQ.
GENERAL MOTORS CORPORATION
LEGAL STAFF
MAIL CODE: 482-C23-B21
300 RENAISSANCE CENTER
P.O. BOX 300
DETROIT, MICHIGAN 48265-3000
(313) 665-4714

METHOD AND SYSTEM FOR TESTING CELLULAR NETWORK INTEGRITY USING TELEMATICS

FIELD OF THE INVENTION

This invention relates generally to testing cellular network integrity using telematics. In particular the invention relates to testing cellular network integrity using data from vehicles having installed telematics systems.

BACKGROUND OF THE INVENTION

Information and interactive services available to mobile vehicles are increasing due to the demand of mobile vehicle operators for services such as navigation assistance, directory assistance, vehicle maintenance assistance, roadside assistance, information services assistance, and emergency assistance. These services are accessible via interfaces such as voice-recognition computer applications, touch-screen computer displays, computer keyboards, or a series of buttons on the dashboard or console of a vehicle.

Currently, telematics service call centers, in-vehicle compact disk (CD) or digital video display (DVD) media, web portals, and voice-enabled phone portals provide various types of location services, including driving directions, stolen vehicle tracking, traffic information, weather reports, restaurant guides, ski reports, road condition information, accident updates, street routing, landmark guides, and business finders.

For example, traffic and driving directions can be accessed through a voice portal that uses incoming number identification to generate location information based on the area code or prefix of the phone number, or to access location information stored in a user's profile associated with the phone number. Users can be prompted to enter more details through a voice interface. Other examples are web and wireless portals that offer location-based services such as maps and driving directions where the user enters both a start and an end address. Some of these services can have a voice interface.

Providing these services often requires the use of cleared numbers, i.e., numbers that can be used by any phone on the network regardless of the level of service to which the phone is subscribed. These cleared numbers must be properly loaded in the switches of the cellular networks. If a cleared number, for example a telematics service enrollment number that a subscriber calls to configure existing service with the telematics service provider, is not properly loaded, the user must contact the service provider via a landline phone or other means, sometimes inconveniencing the user.

Other network conditions, for example the accuracy of GPS coordinates stored in cellular network switches, adequacy of cellular and GPS coverage areas, and cellular tower capacity also contribute to customer satisfaction or lack thereof. Assuring the reliability of cellular networks is the responsibility of the various cellular network providers. Nonetheless, a telematics service provider has an interest in data collection related to these network conditions because it allows the telematics service provider to locate cellular network trouble spots and provide that data to the cellular network provider, thereby increasing customer satisfaction and reducing costs of operation.

It is therefore desirable to provide a system and method for testing cellular network integrity using telematics that overcomes the limitations, challenges, and obstacles described above.

SUMMARY OF THE INVENTION

One aspect of the present invention provides a method for testing cellular network integrity using telematics, comprising determining at least one network condition data (i.e., body of facts) at a telematics unit, establishing a data call communication channel between the telematics unit and the telematics call center, and transmitting at least one network condition data to the telematics call center via the established data call communication channel.

Another aspect of the present invention provides a system for testing cellular network integrity using telematics, comprising means for determining at least one network condition data at a telematics unit, means for establishing a data call communication channel between the telematics unit and the telematics call center, and means for transmitting at least one network condition data to the telematics call center via the established data call communication channel.

A third aspect of the present invention provides a computer usable medium including computer program code for testing cellular network integrity using telematics, comprising computer program code for determining at least one network condition data at a telematics unit, computer program code for establishing a data call communication channel between the telematics unit and the telematics call center, and computer program code for transmitting at least one network condition data to the telematics call center via the established data call communication channel.

The aforementioned and other features and advantages of the invention will become further apparent from the following detailed description of the presently preferred embodiment, read in conjunction with the accompanying drawings. The detailed description and drawings are merely illustrative of the invention rather than limiting, the scope of the invention being defined by the appended claims and equivalents thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram of one embodiment of a system for testing cellular network integrity using telematics, in accordance with the present invention; and

FIG. 2 is a flowchart representative of one embodiment of a method for testing cellular network integrity using telematics, in accordance with the present invention.

DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENTS

FIG. 1 illustrates one embodiment of a system for testing cellular network integrity using telematics, in accordance with the present invention at **100**. Cellular network integrity test system **100** includes a mobile vehicle communication unit (MVCU) **110**, a vehicle communication network **112**, a telematics unit **120**, one or more wireless carrier systems **140**, one or more communication networks **142**, one or more land networks **144**, one or more client, personal, or user computers **150**, one or more web-hosting portals **160**, and one or more call centers **170**. In one embodiment, MVCU **110** is implemented as a mobile vehicle equipped with suitable hardware and software for transmitting and receiving voice and data communications. A display may be embedded in MVCU **110**. The display may be a dialed digital display such as a radio unit or an instrument panel. MVCS **100** may include additional components not relevant to the present discussion. Mobile vehicle communication systems and telematics units are known in the art.

MVCU **110** is also referred to as a mobile vehicle in the discussion below. In operation, MVCU **110** may be implemented as a motor vehicle, a marine vehicle, or as an aircraft. MVCU **110** may include additional components not relevant to the present discussion.

MVCU **110**, via a vehicle communication network **112**, sends signals to various units of equipment and systems (detailed below) within MVCU **110** to perform various functions such as unlocking a door, opening the trunk, setting personal comfort settings, and calling from telematics unit **120**. In facilitating interactions among the various communication and electronic modules, vehicle communication network **112** utilizes network interfaces such as controller-area network (CAN), International Organization for Standardization (ISO) Standard 9141, ISO Standard 11898 for high-speed applications, ISO Standard 11519 for lower speed applications, and Society of Automotive Engineers (SAE) Standard J1850 for high-speed and lower speed applications.

MVCU **110**, via telematics unit **120**, sends and receives radio transmissions from wireless carrier system **140**. Wireless carrier system **140** is implemented as any suitable system for transmitting a signal from MVCU **110** to communication network **142**.

Telematics unit **120** includes a digital signal processor (DSP) **122** connected to a wireless modem **124**, a global positioning system (GPS) unit **126**, an in-vehicle memory **128**, a microphone **130**, one or more speakers **132**, and an embedded or in-vehicle mobile phone **134**. In other embodiments, telematics unit **120** may be implemented without one or more of the above listed components such as, for example, speakers **132**. Telematics unit **120** may include additional components not relevant to the present discussion.

In one embodiment, DSP **122** is implemented as a microcontroller, microprocessor, controller, host processor, or vehicle communications processor. In an example, DSP **122** is implemented as an application-specific integrated circuit (ASIC). In another embodiment, DSP **122** is implemented as a processor working in conjunction with a central processing unit (CPU) performing the function of a general purpose processor. GPS unit **126** provides longitude and latitude coordinates of the vehicle responsive to a GPS broadcast signal received

from one or more GPS satellite broadcast systems (not shown). In-vehicle mobile phone **134** is a cellular-type phone such as, for example, an analog, digital, dual-mode, dual-band, multi-mode or multi-band cellular phone.

DSP **122** executes various computer programs that control programming and operational modes of electronic and mechanical systems within MVCU **110**. DSP **122** controls communications (e.g., call signals) between telematics unit **120**, wireless carrier system **140**, and call center **170**. In one embodiment, a voice-recognition application is installed in DSP **122** that can translate human voice input through microphone **130** to digital signals. DSP **122** generates and accepts digital signals transmitted between telematics unit **120** and a vehicle communication network **112** that is connected to various electronic modules in the vehicle. In one embodiment, these digital signals activate the programming mode and operation modes, as well as provide for data transfers. In an example, signals from DSP **122** can be translated into voice messages and sent out through speaker **132**.

Communication network **142** includes services from one or more mobile telephone switching offices and wireless networks. Communication network **142** connects wireless carrier system **140** to land network **144**. Communication network **142** is implemented as any suitable system or collection of systems for connecting wireless carrier system **140** to MVCU **110** and land network **144**.

Land network **144** connects communication network **142** to client computer **150**, web-hosting portal **160**, and call center **170**. In one embodiment, land network **144** is a public-switched telephone network (PSTN). In another embodiment, land network **144** is implemented as an Internet protocol (IP) network. In other embodiments, land network **144** is implemented as a wired network, an optical network, a fiber network, other wireless networks, or any combination thereof. Land network **144** is connected to one or more landline telephones. Communication network **142** and land network **144** connect wireless carrier system **140** to web-hosting portal **160** and call center **170**.

Client, personal, or user computer **150** includes a computer usable medium to execute Internet browser and Internet-access computer programs for sending and receiving data over land network **144** and, optionally, wired or wireless communication networks **142** to web-hosting portal **160**. Personal or client computer **150** sends user preferences to web-hosting portal through a web-page interface using communication standards such as hypertext transport protocol (HTTP), and transport-control protocol and Internet protocol (TCP/IP). In one embodiment, the data includes directives to change certain programming and operational modes of electronic and mechanical systems within MVCU **110**. In operation, a client utilizes computer **150** to initiate setting or re-setting of user preferences for MVCU **110**. User-preference data from client-side software is transmitted to server-side software of web-hosting portal **160**. User-preference data is stored at web-hosting portal **160**.

Web-hosting portal **160** includes one or more data modems **162**, one or more web servers **164**, one or more databases **166**, and a network system **168**. Web-hosting portal **160** is connected directly by wire to call center **170**, or connected by phone lines to land network **144**, which is connected to call center **170**. In an example, web-hosting portal **160** is connected to call center **170** utilizing an IP network. In this example, both components, web-hosting portal **160** and call center **170**, are connected to land network **144** utilizing the IP network. In another example, web-hosting portal **160** is connected to land network **144** by one or more data modems **162**. Land network **144** sends digital data to and receives digital data from modem **162**, data that is then transferred to web server **164**. Modem **162** may reside inside web server **164**. Land network **144** transmits data communications between web-hosting portal **160** and call center **170**.

Web server **164** receives user-preference data from user computer **150** via land network **144**. In alternative embodiments, computer **150** includes a wireless modem to send data to web-hosting portal **160** through a wireless communication network **142** and a land network **144**. Data is received by land network **144** and sent to one or more web servers **164**. In one embodiment, web server **164** is implemented as any suitable hardware and software capable of providing web services to help change and transmit personal preference settings from a client at computer **150** to telematics unit **120** in MVCU **110**. Web server **164** sends to or receives from one or more databases **166** data transmissions via network system **168**. Web server **164** includes computer applications and files for managing and storing personalization settings supplied by the client, such as door lock/unlock behavior, radio station preset selections, climate controls, custom button configurations, and theft alarm settings. For each client, the web server potentially stores hundreds of preferences for wireless vehicle communication, networking, maintenance and diagnostic services for a mobile vehicle.

In one embodiment, one or more web servers **164** are networked via network system **168** to distribute user-preference data among its network components such as database **166**. In an example, database **166** is a part of or a separate computer from web server **164**. Web server **164** sends data transmissions with user preferences to call center **170** through land network **144**.

Call center **170** is a location where many calls are received and serviced at the same time, or where many calls are sent at the same time. In one embodiment, the call center is a telematics call center, facilitating communications to and from telematics unit **120** in MVCU **110**. In an example, the call center is a voice call center, providing verbal communications between an advisor in the call center and a subscriber in a mobile vehicle. In another example, the call center contains each of these functions. In other embodiments, call center **170** and web-hosting portal **160** are located in the same or different facilities.

Call center **170** contains one or more voice and data switches **172**, one or more communication services managers **174**, one or more communication services databases **176**, one or more communication services advisors **178**, and one or more network systems **180**.

Switch **172** of call center **170** connects to land network **144**. Switch **172** transmits voice or data transmissions from call center **170**, and receives voice or data transmissions from telematics unit **120** in MVCU **110** through wireless carrier system **140**, communication network **142**, and land network **144**. Switch **172** receives data transmissions from and sends data transmissions to one or more web-hosting portals **160**. Switch **172** receives data transmissions from or sends data transmissions to one or more communication services managers **174** via one or more network systems **180**.

Communication services manager **174** is any suitable hardware and software capable of providing requested communication services to telematics unit **120** in MVCU **110**. Communication services manager **174** sends to or receives from one or more communication services databases **176** data transmissions via network system **180**. Communication services manager **174** sends to or receives from one or more communication services advisors **178** data transmissions via network system **180**. Communication services database **176** sends to or receives from communication services advisor **178** data transmissions via network system **180**. Communication services advisor **178** receives from or sends to switch **172** voice or data transmissions.

Communication services manager **174** provides one or more of a variety of services, including enrollment services, navigation assistance, directory assistance, roadside assistance, business or residential assistance, information services assistance, emergency assistance, and communications assistance. Communication services manager **174** receives service-preference requests for a variety of services from the client via computer **150**, web-hosting portal **160**, and land network **144**. Communication services manager **174** transmits user-

preference and other data to telematics unit **120** in MVCU **110** through wireless carrier system **140**, communication network **142**, land network **144**, voice and data switch **172**, and network system **180**. Communication services manager **174** stores or retrieves data and information from communication services database **176**. Communication services manager **174** may provide requested information to communication services advisor **178**.

In one embodiment, communication services advisor **178** is implemented as a real advisor. In an example, a real advisor is a human being in verbal communication with a user or subscriber (e.g., a client) in MVCU **110** via telematics unit **120**. In another embodiment, communication services advisor **178** is implemented as a virtual advisor. In an example, a virtual advisor is implemented as a synthesized voice interface responding to requests from telematics unit **120** in MVCU **110**.

Communication services advisor **178** provides services to telematics unit **120** in MVCU **110**. Services provided by communication services advisor **178** include enrollment services, navigation assistance, real-time traffic advisories, directory assistance, roadside assistance, business or residential assistance, information services assistance, emergency assistance, and communications assistance. Communication services advisor **178** communicates with telematics unit **120** in MVCU **110** through wireless carrier system **140**, communication network **142**, land network **144** and web hosting portals **160** using voice transmissions. In an alternative embodiment, communication services manager **174** communicates with telematics unit **120** in MVCU **110** through wireless carrier system **140**, communication network **142**, land network **144,** and web hosting portals **160** using voice transmissions. Switch **172** selects between voice transmissions and data transmissions.

Cleared number data call connections are used to provide for data uploads from MVCU **110** to call center **170**. A cleared number is a number that can be used by any phone on the network regardless of the level of service to which the phone is subscribed. Telematics service providers and other users of the cellular networks make requests for cleared numbers. Examples of cleared numbers are cellular service enrollment numbers and telematics configuration numbers. Cleared numbers are loaded in the cellular network switches of a wireless carrier system **140** by the cellular network provider responsible for those switches.

A cleared number data call connection is established by opening a communication channel from mobile MVCU **110** via telematics unit **120** through at least one of wireless carrier system **140**, communication network **142,** and land network **144** to web hosting portal **160** or call center **170**. The cleared number data call connection is initiated by placing a cleared number data call using a cleared number. The cleared number is a number defined in the cellular network switches of wireless carrier system **140** as a cleared number.

During a cleared number data call, MVCU **110** connects to wireless carrier system **140** by communication channel **111**. Wireless carrier system **140** connects to communication network **142** by communication channel **141**. Communication network **142** connects to land network **144** by communication channel **151**. Land network **144** connects to call center **170** by communication channel **171** or to web hosting portal **160** by communication channel **161**. Communication channel **161** can also include communication from land network **144** to web hosting portal **160** and from web hosting portal **160** to call center **170**.

A cleared number data call is established by an exchange of handshakes between a wireless modem **124** and a data modem **162** or other modem in call center **170**. When receiving a cleared number data call, the call center **170** does not trigger software that places an electronic request for MVCU **110** telematics unit identifiers from the telematics unit **120**. These identifiers allow the telematics service provider to determine what services the subscriber has purchased. Services provided through cleared numbers do not require authentication because knowledge of the level of service to which a subscriber is enrolled is not required for these services. A cleared number is sometimes referred to as a non-validating number because the call center does not validate the identity of the caller or the identity of the telematics unit initiating the call. A telematics unit in any MVCU **110** can initiate a cleared number data call. Once the cleared number data call is established, network condition data can be sent over the resulting cleared number data connection.

In the event that one of the communication channels **111**, **141**, **151**, **161** is not connected, a cleared number communication channel from mobile MVCU **110** to call center **170** is not established. After a predetermined number of failures to establish a cleared number data communication channel, the telematics unit **120** will discontinue attempts to establish the connection.

FIG. 2 illustrates a flowchart representative of one embodiment of a method **200** for testing cellular network integrity using telematics in accordance with the present invention.

The method, which begins at **201**, is exclusive of any tools employed by cellular network providers for testing their networks. Cellular network providers are responsible for the integrity of the cellular networks. As an end user of cellular network services, a telematics service provider is concerned about network integrity for maintenance of customer satisfaction. The present invention leverages the abundance of telematics units dispersed throughout a particular

area to provide data points for assessing network integrity. The collected information is maintained in a database and can be communicated to cellular network providers as needed.

During step **205**, the telematics unit determines network condition data. Network condition data (i.e., a body of facts regarding a network condition) comprises one or more types of data selected from the group consisting of a properly loaded number verification, a measured and stored GPS coordinate comparison, a cellular traffic load measurement, a no-cellular-coverage-area identification, and a no-GPS-coverage-area identification.

In one embodiment, the network condition for which data is determined is the proper loading of cleared numbers within a local cellular switching network. As discussed above, a cleared number data call does not require authentication at the telematics call center, thereby eliminating the need for call center advisor **178** or subscriber intervention.

The telematics unit **120** initiates a test to verify proper loading of a number by initiating a call to at least one number from a list of cleared numbers stored in the telematics unit. In one embodiment, the number is a cleared number. When a call fails for lack of a properly loaded number, the telematics unit **120** receives a signal indicating that it is not authorized to place the call. If the telematics unit **120** receives such a signal, the unit generates a memory record containing the number that could not be accessed, the GPS coordinates of the telematics unit **120** at the time the call was placed, and the time that the call was placed.

During step **210**, the telematics unit **120** attempts to transmit at least one number data call to the telematics call center **170**. In one embodiment, the number data call is a cleared number data call. In one embodiment the number data call is initiated in response to a predetermined time increment programmed in the telematics unit **120**. In another embodiment the number data call is initiated in response to the MVCU **110** arriving at a predetermined test point as defined by stored GPS coordinates. In additional embodiments, other call

triggers are used such as miles elapsed by MVCU **110**, or a trigger signal transmitted from a call center **170** where the trigger signal is based on a physical, logical, or temporal event.

During step **220**, a data call communication channel is either established or fails to establish. In one embodiment, the data call communication channel is a cleared number data call communication channel. If the telematics unit **120** detects a data call communication channel comprising communication channels **111**,**141**, **151**, and **171** between the telematics unit **120** and the call center **170**, the telematics unit **120** transmits the network conditicn data to the telematics call center **170** via the established data call communication channel during step **230**. The network data condition is stored in one or more databases **176** at call center **170** or in one or more databases **166** at web-hosting portal **160**.

Alternatively, if a data call communication channel is not established, the telematics unit **120** recognizes a failure to establish the data call communication channel from the telematics unit **120** to the telematics call center **170** during step **280**.

During step **285**, upon recognition of the failure to establish the data call from the telematics unit **120** to the telematics call center **170**, the telematics unit creates a data upload failure record in in-vehicle memory **128**. The data upload failure record comprises the time the recognized failure occurred, the determined network data condition, and a retry counter that indicates the number of times the data upload failure occurred. The data upload failure record is sent to the telematics call center **170** at a predetermined future time. Examples of times the data upload failure record is subsequently sent to the call center **170** are during the next scheduled data call, upon receiving a request sent from the call center to initiate the cleared number data call, or when the telematics unit **120** recognizes it has data for transmittal to the call center **170**. In another embodiment, the telematics unit **120** attempts to establish the data call a predetermined number of times before writing the data upload failure record in in-vehicle memory **128** for sending at future time.

During step **295**, the flow of method **200** is terminated.

In another embodiment, the network condition for which data is determined is cellular traffic load. When a telematics unit places a data call, such as, for example, a cleared number data call, the success or failure of the connection, including the number of retries attempted, is affected by cellular tower saturation. Cellular tower saturation is typically an issue only at peak traffic periods, such as rush hour in a metropolitan area. Each time a data call is attempted, the telematics unit generates a memory record containing the success or failure of establishing a valid connection using the number, the number of retries attempted, the location of the telematics unit at the time the call was placed, and the time the call was placed. The cellular traffic load measurement when combined with similar measurements obtained from multiple vehicles is used to estimate cellular tower saturation at various times of the day in a particular geographic location. The information is transmitted to a call center as described in the previous embodiment.

In yet another embodiment, the network condition data relates to identification of no-cellular-coverage areas. If the telematics unit **120** is located in an area with no cellular coverage it will fail to receive a signal on a control channel, preventing the telematics unit **120** from placing a data call. The telematics unit will generate a memory record containing the failure to receive the signal on a control channel for placing the cleared number call, the GPS coordinates of the telematics unit at the time the call was attempted, and the time the call was attempted. In another embodiment the telematics unit **120** can monitor and record signal strength and flag locations where no signal is detected. In another embodiment, the telematics unit also includes in the memory record a real-time measurement of the cellular signal strength at the time the call was attempted. Information regarding the network condition is reported to a call center as described above.

In still another embodiment, the network condition is a no-GPS-coverage area. If the telematics unit **120** is located in an area with no GPS coverage, it will fail to receive GPS coordinates when querying the GPS unit **126** of the telematics unit **120**. When this occurs, the telematics unit **120** generates a memory record containing the failure to receive GPS coordinates, the last known GPS coordinates of the telematics unit prior to the GPS query failure, and the time the GPS query was attempted. The information collected is reported to a call center as described above. By using data from multiple vehicles within a particular geographic area, the call center determines the location of the no-GPS-coverage area.

In another embodiment, the network condition data is a measured and stored GPS coordinate comparison. On cellular networks a system identification (SID) is a 15 bit number (0-32767) transmitted by every AMPS, N-AMPS, TDMA (ANSI-136) and CDMA (ANSI-95, IS-2000) base station to identify a portion (or all) of a carrier's network. Reception of the transmitted SID by a cellular handset or a telematics unit allows the unit to determine if it is located in its home service area. If a cellular handset or telematics unit **120** receives its home SID, it is not roaming and can determine the geographic area in which it is currently located. The information collected is reported to a call center as described above.

Within a telematics unit, the geographic area encompassed by a particular SID is defined by a range of GPS coordinates associated with that particular SID and stored in the telematics unit. If the GPS coordinates obtained from the GPS unit **126** in the telematics unit **120** do not fall in the range of GPS coordinates associated with a received SID, a failure is noted for the measured and stored GPS coordinate comparison. The telematics unit generates a memory record containing the measured GPS coordinates from the GPS unit of the telematics unit, the received SID, the range of GPS coordinates associated with the received SID, and the time the comparison was made. The information collected is reported to a call center as described above.

While the embodiments of the invention disclosed herein are presently considered to be preferred, various changes and modifications can be made without departing from the spirit and scope of the invention. The scope of the invention is indicated in the appended claims, and all changes that come within the meaning and range of equivalents are intended to be embraced therein.